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# RECOLONIZATION OF MACROINVERTEBRATES AND FISH IN A CHANNELIZED STREAM AFTER A DROUGHT[1]

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ABSTRACT. The channelized portion of the Little Auglaize River became completely dewatered during a summer drought in 1974. Low water levels were maintained in the undisturbed area upstream, but the abundance and diversity of biota there were reduced. The biota of the channelized area appeared to recover to near normal levels within a year as species recolonized it from the Auglaize River. The unchannelized area was not open to the refugia provided by the Auglaize River because a low head dam occurred below it which was not navigable by fish. Macrobenthos recovered within a year to near normal levels in the unchannelized area but fish appeared to remain at reduced levels. The provision of biological refugia in the form of unchannelized receiving streams, unchannelized tributary streams of equal stream order or unmodified stream sections within channelization projects is necessary to insure continued biological integrity in small channelized streams draining agricultural watersheds.

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## INTRODUCTION

Stream channelization has had severe environmental impacts on our nation's waterways. Direct effects on fish and invertebrate populations have been well documented. Reduced benthic drift and changes in invertebrate communities in channelized stream sections have been found (Morris et al. 1968, Etneir 1972). Channelization may also reduce the densities of both cold- and warm-water fish (Bayless and Smith 1964, Elser 1968, Irizarry 1969, Congdon 1971, Tarplee et al. 1971, Trautman and Gartman 1974 and Lund 1976), as well as their growth rates (Purkett 1957, Hansen 1971 and Arner et al. 1975).

More subtle indirect effects on biota include those associated with development of potentially hazardous floodplain areas, increased downstream flooding, promotion of wetland drainage and woodland destruction, reduction of groundwater levels, and increased erosion (Barstow 1971, Emerson 1971, Hansen 1971 and Henegar and Harmon 1971). This paper will explore the effects of drought on the fauna in natural and channelized sections of the Little Auglaize River, a typical medium-sized warm-water stream in northwest Ohio. This stream drains land devoted to intensive agriculture.

## STUDY SITE

The source of the Little Auglaize River is in southern Van Wert County in northwest Ohio. The river flows northerly through Putnam County and empties into the Auglaize River, a tributary of the Maumee River in eastern Paulding County (fig. 1). The watershed is intensively farmed. The soils are highly fertile lacus-

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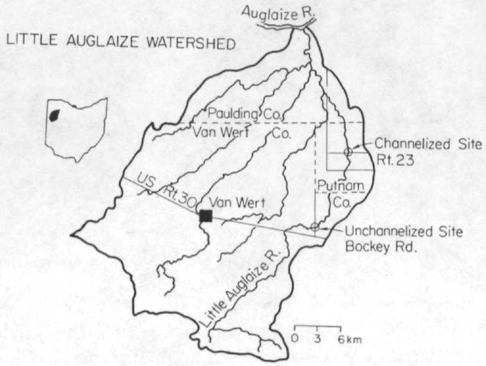


FIGURE 1. Location of sampling areas within the Little Auglaize watershed.

trine deposits of Glacial Lake Maumee. The remaining timber in the watershed is confined to stream banks and small isolated woodlots. Water quality is good, but suspended solids and turbidity are sometimes high.

To improve drainage, the US Soil Conservation Service channelized 35 km of the stream immediately downstream from the Van Wert-Putnam County Line in 1970-71. Historical records indicated that the entire stream had once been modified, but there had been no modification upstream from the county line for at least 30 years. A control site was selected 6 km upstream and a channelized site 4 km downstream from the county line. A lowhead mill dam (maximum height 0.5 m) was located between the areas, and another 2.5 km downstream from the channelized site (maximum height 0.3 m). Both dams may be completely covered by water at maximum discharge.

The unchannelized control site, located at the Bockey Road bridge crossing, was 150 m long; mean depth was 0.5 m and pools were as deep as 1.2 m. The flow characteristics of the site were not affected by the mill dam 4 km below. The substrate was cobble embedded in compacted clay. Canopy from overhanging deciduous trees was moderate to heavy, and the rooted aquatic plant, *Saururus cernuus* (lizard tail), was common throughout (fig. 2).

FIGURE 2. The unchannelized sampling area in the Little Auglaize River, Ohio (see fig. 1 for location).

The channelized section extended for 150 m immediately downstream from the Highway R-23 bridge crossing in Putnam County. The stream was uniformly 10 m wide and 0.3-0.5 m deep during mean flow. All woody vegetation had been removed and the banks had been planted in grasses (fig. 3). The substrate was compacted silty clay over limestone bedrock with isolated areas of sand/gravel overburden. Substrate in areas of more rapid flow was exposed bedrock. Both sections were third order streams as classified by the Strahler modification of Horton's stream classification system (Strahler 1957).

In midsummer 1974, the entire channelized portion of the Little Auglaize River was completely dry for nearly 2 months as the result of an extended drought from June through August, when rainfall totaled 12.8 cm compared with a normal

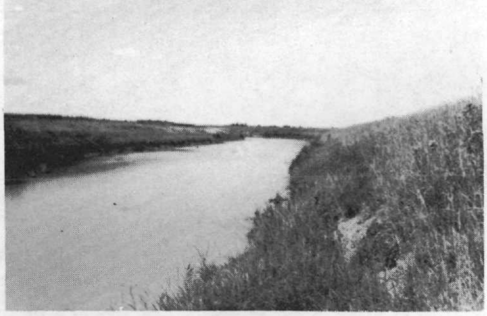

FIGURE 3. The channelized sampling area in the Little Auglaize River, Ohio (see fig. 1 for location).

rainfall of 26.3 cm (table 1, fig. 4). Standing water in the control section was limited to the deeper pools (fig. 5).

## METHODS AND MATERIALS

Collections of macrobenthos and aquatic drift were made in June 1974 and monthly from April – October in 1975. Samples were collected with square-foot Surber samplers and drift nets with openings of 0.305 m and 253-micron mesh. Four samples were taken at each station, and two 10-min drift samples were collected at 6-h intervals for 24 h during each period.

Organisms were sorted, identified to family, counted and weighed. Identification only to the familial level was justified by previous work which showed negligible increased diversity at the species level and strong correlation between diversity indices calculated for specific, generic, and familial levels (Kaesler and Herricks 1976). Replicates within each area on each sampling date were pooled to form a sample. Since effort for each area on each date was equal, data are expressed in total numbers and total biomass.

Fishes in each area were sampled on 3 June 1974, 30 April, 29 July and 1 November 1975, with pulsed DC electrofishing equipment. The areas were isolated with blocking nets and fished exhaustively throughout. Fish were identified, measured, weighed and released. Electrofishing time was recorded and catch per minute calculated.

Characteristics derived from macroinvertebrate data included number of families and total number and biomass of individuals per family. Shannon-Weaver diversity indices were modified for familial diversity ($\overline{H}$) by Pielou (1966) and computed as follows:

$$\overline{H} = \sum_{1}^{Si} (N_i/N)\log(N_i/N)$$

where $N$ is the number of individuals in $S$ families and $Ni$ is the number of individuals in the $i^{th}$ family. The L-statistic of Page (1963) was calculated to compare treatment effect on relative abundance and biomass, and the non-parametric Friedman rank sums test (Hollander and Wolfe 1973) was used to make multiple comparisons and derive probability levels when Page's L-statistic indicated significant differences among treatments.

TABLE 1

*Monthly rainfall in 1974 (mm) and average total monthly rainfall at the Van Wert, OH, weather station.*

| Month | 1974 | Historical Mean |
|---|---|---|
| January | 8.5 | 6.4 |
| February | 5.6 | 5.2 |
| March | 10.1 | 8.0 |
| April | 8.0 | 9.8 |
| May | 11.8 | 10.6 |
| June | 6.2 | 10.9 |
| July | 0.8 | 9.4 |
| August | 5.8 | 6.0 |
| September | 7.1 | 7.6 |
| October | 2.2 | 7.0 |
| November | 8.8 | 7.0 |
| December | 9.8 | 5.6 |
| Total Rainfall | 83.8 | 93.6 |

FIGURE 4. The channelization area of the Little Auglaize River during drought in summer 1974.

## RESULTS

No statistical inferences could be made concerning differences in macrobenthos populations in the 2 areas in 1974 because sampling was limited due to dry riverbed conditions. Macroinvertebrates ($n$ = 171) of 8 families were identified in samples from the channelized section and 115

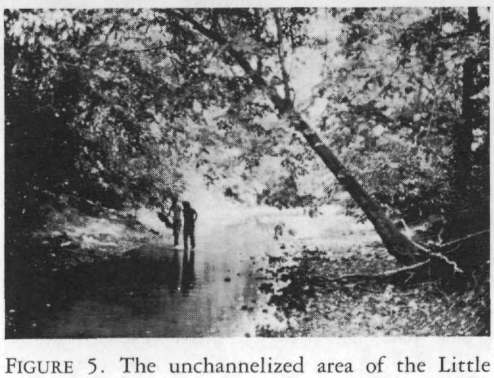

FIGURE 5. The unchannelized area of the Little Auglaize River during 1974 drought (photograph taken on same day as fig. 4).

representing 6 families were collected in samples from the unchannelized area in June.

In 1975, 14 taxa were identified from each area, but significantly ($P<0.05$) more individuals were taken in the channelized area (table 2). Multiple comparisons indicated that oligochaetes, simuliids, baetids and hydropsychids contributed significantly more individuals ($P<0.05$) in this area. Total biomass collected with Surber samplers was nearly equal in both areas–9.75 g in the control area and 9.25 g in the channelized area. Individual benthic family diversity indices in 1975 were 3.02 in the channelized area and 2.23 in the unchannelized area, a significant difference ($P<0.05$).

Drift sampling in 1974 was also limited by the drought and quantitative analysis was precluded. In the single 24-h drift sample attempted, 619 organisms of 17 taxa were collected in the unchannelized area and 205 from 9 taxa in the channelized area.

In 1975, drift expressed in numbers of taxa and numbers of organisms (table 2) was greater in the unchannelized area than in the channelized area ($P<0.01$). Chironomids were significantly more abundant in the unchannelized area ($P<0.01$) and largely accounted for the difference. Except for Oligochaeta, all major taxa were also equally or more abundant in the unchannelized area. Total biomass in the drift from the unchannelized area (4.50 g) was nearly 5 times greater than that collected in the channelized area (0.95 g).

No quantitative data on fish populations were collected in 1974 because by mid-June, fishes in the channelized portion were confined to a few isolated pools and were limited to species that are especially tolerant of low dissolved oxygen and high temperature (water temperatures then reached 23.3 C in these pools). In contrast, maximum water temperature at the Bockey Road control area at that time was 17.2 C, and other stream conditions appeared normal. By early July, the channelized stream bed was completely dry and devoid of fish life; whereas, in the unchannelized area upstream, fish had congregated in the relatively cool discontinuous pools. The maximum water temperature in the unchannelized area (24.7 C) was recorded on 26 July 1974. These conditions prevailed until August. Although considerable mortality probably occurred in the pools in the unchannelized area, live individuals of several species were seen throughout the drought period.

Fish populations in the channelized area had recovered by the summer of 1975 (table 3). Thirty species were represented in the samples taken, and the catch per minute (CPM) of a number of species was high. The catch consisted primarily of cyprinids, catostomids and shad. Gamefish were uncommon. CPM for most species in the unchannelized area was comparatively low, and species collected there were generally limited to some of the more abundant species that occurred in the

TABLE 2

*Number of benthic and drift organisms collected in unchannelized and channelized areas of the Little Auglaize River, OH, April–October 1975.*

| Taxa | Unchannelized Area | | Channelized Area | |
|---|---|---|---|---|
| | Benthos | Drift | Benthos | Drift |
| Asellidae | 100 | 36 | 32 | 0 |
| Astacidae | 7 | 0 | 8 | 0 |
| Baetidae | 35 | 192 | 162 | 146 |
| Bivalvia | 10 | 4 | 0 | 0 |
| Chironomidae | 553 | 3969 | 430 | 602 |
| Corixidae | 2 | 64 | 14 | 13 |
| Culicidae | 0 | 30 | 0 | 30 |
| Elmidae | 11 | 134 | 77 | 30 |
| Gastropoda | 42 | 8 | 4 | 0 |
| Heleidae | 0 | 0 | 0 | 17 |
| Heptageniidae | 292 | 69 | 91 | 37 |
| Hydropsychidae | 39 | 119 | 179 | 8 |
| Oligochaeta | 87 | 154 | 415 | 573 |
| Perlidae | 11 | 3 | 27 | 0 |
| Ptilidae | 0 | 0 | 247 | 0 |
| Simulidae | 0 | 29 | 304 | 24 |
| Other | 3 | 38 | 5 | 6 |
| Total No. | 1192 | 4858 | 1986 | 1486 |
| Total Taxa | 14 | 29 | 14 | 16 |

channelized area downstream. Stream survey records made available by the Ohio Division of Wildlife (ODW) indicate that a dozen additional species were common to abundant in the general area of the unchannelized site as recently as 1973. These were generally less tolerant species that apparently perished during the drought and had not repopulated the area. Repopulation rates of the unchannelized area from below were probably limited by the low-head dams.

## DISCUSSION

Drought conditions probably led to intolerable thermal stress and/or dissolved oxygen levels for both macrobenthos and fish before complete dewatering of the entire channelized section. Pre-drought conditions in the unchannelized area are difficult to document because so little sampling was done before the drought.

Macrobenthos populations recovered from drought conditions within 1 year in

TABLE 3.

*Cumulative catch of fish by electrofishing channelized and unchannelized areas of the Little Auglaize River, Ohio, in 1975. (Names taken from American Fisheries Society 1970.)*

| Species | Unchannelized | | Channelized | |
|---|---|---|---|---|
| | Total Number | Number/ Minute | Total Number | Number/ Minute |
| *Dorosoma cepedianum* | –* | – | 445 | 3.4 |
| *Esox americanus vermiculatus* | 26 | 0.2 | 1 | >0.1 |
| *Campostoma anomalum* | – | – | 15 | 0.1 |
| *Cyprinus carpio* | 102 | 0.9 | 289 | 2.2 |
| *Ericymba buccata* | – | – | 270 | 2.0 |
| *Notropis atherinoides* | – | – | 1 | >0.1 |
| *N. spilopterus* | – | – | 37 | 0.3 |
| *N. stramineus* | – | – | 1305 | 9.9 |
| *N. umbratillis* | 85 | 0.7 | 234 | 1.8 |
| *Phenacobious mirabilis* | – | – | 24 | 0.2 |
| *Pimephales notatus* | 68 | 0.6 | 2973 | 22.5 |
| *P. promelas* | 5 | >0.1 | 208 | 1.6 |
| *Semotilus atromaculatus* | 23 | 0.2 | 352 | 2.7 |
| *Carpiodes cyprinus* | – | – | 62 | 0.5 |
| *Catostomus commersoni* | 83 | 0.7 | 128 | 1.0 |
| *Ictalurus melas* | 2 | >0.1 | 24 | 0.2 |
| *I. natalis* | 10 | 0.1 | 11 | 0.1 |
| *I. punctatus* | – | – | 1 | >0.1 |
| *Noturus gyrinus* | – | – | 3 | >0.1 |
| *Fundulus notatus* | – | – | 3 | >0.1 |
| *Lepomis cynaellus* | 175 | 1.5 | 310 | 2.3 |
| *L. humilis* | – | – | 227 | 1.7 |
| *L. macrochirus* | – | – | 1 | >0.1 |
| *Micropterus salmoides* | – | – | 7 | 0.1 |
| *Pomoxis migromaculatus* | – | – | 1 | >0.1 |
| *P. annularis* | – | – | 3 | >0.1 |
| *Etheostoma blennioides* | – | – | 1 | >0.1 |
| *E. nigrum* | 7 | 0.1 | 90 | 0.7 |
| *Percina caproides* | – | – | 10 | 0.1 |
| *P. maculata* | 4 | >0.1 | 19 | 0.1 |
| Total | 590 | 4.99 | 7055 | 53.45 |
| Total Fishing Time (min) | 118.2 | | 132.0 | |

*Species not collected

terms of total numbers and biomass. Community structure was quite different between the 2 areas with "riffle species" such as heptageniids, aselliids and mollusks being more prevalent in the unchannelized area. These differences were probably due more to differences in habitat between areas than to drought effects. Drift was significantly higher in the unchannelized area, but this was due to tremendous numbers of only one taxa, Chironomidae, in the drift.

Comparison of post-drought data with historical state fishery survey records indicates that the drought induced severe, although incomplete fish mortality in the unchannelized area. In 1975, fish populations were considerably larger and more diverse in the channelized area than in the unchannelized area. Fish populations in the unchannelized area did not approximate those indicated by Ohio survey records in the early 1970s. Recovery of the fish community in the channelized area, which is open to the Maumee River system, seemed rapid since 1975 samples from these populations were similar to historical State survey records. The control area which is separated from the Maumee by 2 low-head dams, had no refugia from which repopulation might originate, and recovery was slow. While the channelized area is also separated from the lower river by 1 dam, it is hypothesized that this dam could have been navigated by fish during spring high water, while the second dam, further upstream, could not.

Channelization may drain small- to moderate-sized watersheds so efficiently as to dewater associated stream channels under drought conditions. The provision of refuges for aquatic biota is important. These may be in the form of direct access to unchannelized receiving streams, unchannelized tributary streams of equal stream order or equivalent size, or unmodified stream sections within sizable channelization projects.

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